Fact Sheet:

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Containerless Coating Process (CONCOP) for Extraterrestrial Structures

The Problem

Lightweight, high-stiffness materials are used in extraterrestrial structures, such as orbiting satellites; platforms for reconnaissance, surveillance, target acquisition, communication, and navigation; environmental monitoring purposes; and planetary surface systems, such as shelters for equipment, habitability modules, or electronic components. These materials are subject to degradation caused by atomic oxygen and ultraviolet radiation, micro-cracking induced by thermal cycling, and impact damage caused by collision with space debris. Sensitive electronic devices within these space structures are also subject to degradation.

A protective coating applied to these space structures would protect them, and their associated electronic components, from the harsh space environment in the same way paint and anti-corrosive coatings protect terrestrial, or earth-based, structures. If coated, extraterrestrial structures would require routine re-coatings, just as terrestrial structures require repainting. Returning these extraterrestrial structures to the earth for repair or refurbishment would be impractical and prohibitively expensive, if not impossible.

The Technology

The U.S. Army Construction Engineering Research Laboratories (CERL) has proposed applying protective coatings in space. This in-space containerless coating process (CONCOP) would use innovative adaptations of standard metal and ceramic vapor deposition techniques, which are conducted on earth at very low pressures (around one-billionth of atmospheric pressure) in high vacuum chambers. High vacuum, or low pressure, levels occur naturally in low earth orbit (around 200-300 miles above the surface of the earth); therefore, no specialized vacuum chambers/containers or pumps would be required for the in-space coating process.

Using these techniques, vapor deposited surfaces would be applied to extraterrestrial structures to protect them against space environmental degradation or to form electrically conductive or reflective surfaces for antennas, mirrors, or heat radiators. Based on the results of previous studies and materials processing in space experiments by other researchers, there is good reason to believe that the microgravity environment of low earth orbit may favorably affect the quality of thin film coatings.

Benefits/Savings

Development of an in-space CONCOP will provide an alternative to returning space structures to the earth for repair. Also, this coating technology may provide the only means of protecting and increasing the stiffness of complex shaped surfaces, cul-de-sacs, and small crevices between joints that are created as the structures are assembled or deployed in orbit or on lunar and planetary surfaces. Furthermore, CONCOP can be integrated with innovative space-based manufacturing processes to produce advanced microelectronic devices which can be used in space-based or earth-based electronic systems.

Status

In February 1994, CERL conducted a proof-of-principle CONCOP experiment as one of several companion experiments to the first Wake Shield Facility (WSF) mission on Space Shuttle Mission STS-60.

The CONCOP experiment was conducted in the vacuum environment of the space shuttle Discovery's cargo bay. It was be packaged in a WSF Smart Payload Canister and opened to the low earth orbit environment, allowing the low pressure atmosphere into its vapor deposition region. A hot tungsten filament was activated in order to evaporate aluminum onto various specimens (or substrates) which are representative of materials used in extraterrestrial structures (i.e., polymers, composites, and ceramics). In March 1994, the CONCOP hardware and the space-coated substrates were returned to CERL. The experimental data have been analyzed.

The CONCOP experiment results will be used in preparing for follow up thin film coating experiments to be deployed outside the shuttle cargo bay in conjunction with future NASA WSF experiments. Follow up experiments could be more sophisticated in scope and may employ a combination of surface-modification techniques, such as ion implantation, filament vapor deposition, ion beam mixing, sputter deposition, and sputter-cleaning.

Lessons learned from these CONCOP experiments will be used to develop hardware for routine construction and maintenance of extraterrestrial structures essential to military and civil space programs.

As a result of the Tri-service Reliance Study, CERL's large space structure's mission was relinquished to the U.S. Air Force in 1991. A Memorandum of Agreement is now pending to loan the CONCOP hardware to one of the NASA Centers for Commercial Development of Space.

Point of Contact

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